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Effect of fly ash on the feeding activity of brown planthopper and defence chemicals in rice plant

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ABSTRACT

Pot culture experiment and laboratory experiments were carried out to study the feeding activity of brown plant hopper through honey dew test and certain biochemical constituents in the rice plant due to the application of fly ash. Among the various treatments, quantity of honey dew excreted in terms of area was significantly less in lignite fly ash (LFA) at 10 t ha^{-1} (9.6 mm^2) followed by LFA 12.5 t ha^{-1} (10mm^2) as against the maximum of 51.6 mm^2 in the untreated check. Honey dew excreted in the treatments bituminous fly ash (BFA) at 12.5 t ha^{-1} and 10 t ha^{-1} were 11.0 and 11.6mm^2, respectively and these two treatments were on par with each other. The biochemical constituents of plants imposed with fly ash revealed that total phenol content, silicon and tannin content varied significantly among the treatments. Total phenol content was significantly high in LFA at 10 t ha^{-1} (6.03 mg g^{-1}) and LFA at 12.5 t ha^{-1} (5.9 mg g^{-1}) followed by BFA 12.5 t ha^{-1} (5.4 mg g^{-1}), against the minimum of untreated check (2.06 mg g^{-1}). Silicon content was significantly high in LFA 10 t ha^{-1} (2.6 %) and BFA 12.5t ha^{-1} (2.5 %) as against the minimum of 1.0% in the untreated check. Tannin content was significantly high in LFA 7.5 t ha^{-1}(9.1 mg g^{-1}) and 12.5 t ha^{-1} (8.46 mg g^{-1}) as against the minimum of untreated check (2.43 mg g^{-1}). Similarly BFA and LFA at 1 t ha^{-1} and 2.5 t ha^{-1} were significantly on par with each other and their phenol, silicon and tannin content were comparatively lower than the high doses.

Key words: *BPH, honey dew, fly ash, biochemical constituents*

Fly ash is a residue of burning of coal and lignite, the organic sources of energy. The micro and macro nutrients present in coal get concentrated in ash. Chemical composition of fly ash is silicon 15-45%, Fe_2O_3 4-5%, Al_2O_3 20-25%, CaO 15-40%. Narayansamy (1995) stated that the silica content of fly ash has got translocated to the plant system which increases the layers of sclerenchymatous cells especially in culms and leaves which in turn induces resistance in the rice plant to the problems of BPH, GLH and other sucking insects. Murugesan *et al*. (1995) proved the reduction of BPH population in fly ash treated plants and also revealed significantly less feeding in the honey dew test. The reduction was due to antibiosis exhibited by the changes in biochemical content.

Among the pests of rice, the brown plant hopper once considered to be a minor pest in India has became a major pest in south and south east Asia during the last two decades. Large scale damage by the insect has been reported in India, Indonesia, Philippines and Sri Lanka. The insect damage the crop by direct feeding and also by acting as vector for some viral diseases like grassy stunt, ragged stunt and wilted stunt (Nault and Ammar, 1989)

Exploitation of host resistance is a major component of IPM. Plant resistance is a most economic and desirable method for the management of pests. In the absence of natural heritable resistance, creating induced resistance in plants to pests by the nutritional manipulation is one of the promising supplements in encountering the pests. Measurement of honeydew excretion and number of probing marks made by BPH is used as a tool to assess the resistance and susceptibility of breeding lines. Mallika and Ramabadran (1995) studied the influence of graded levels of lignite fly ash (LFA) on the yield and reported that increased application of LFA decreased sugar and increased the

starch, phenol and thousand grain weight. In rice plants, supply of Si also changed the contents of carbohydrate, protein, phenol and these changes varied slightly with the stage of the crop and plant part (Ashoka Rani *et al*., 1997). Hence with a view to document the effects of soil application of fly ash against BPH in rice plant, the present work was carried out with the objectives, *i.e.* to study the influence of fly ash on the feeding activity of BPH through honey dew test; to estimate the biochemical contents *viz.*, phenol, silicon and tannin as influenced by fly ash application

MATERIALS AND METHODS

Pot experiment and laboratory experiments were conducted at Agricultural College and Research Institute, Madurai to study the effect of fly ash on the feeding activity of BPH and to estimate the biochemical constituents in rice plant as influenced by the addition of fly ash.

Twenty days old Jeeraga samba seedlings were transplanted into micro plots size of 0.5 × 0.5 × 0.4 m with a spacing of 20 x 20 cm. The treatments as indicated below were imposed basally in soil before transplanting in microplots. Four hills were maintained uniformly in each micro plot and two seedlings were maintained hill^{-1}. The experiment was carried out in completely randomized block design with three replications. Twenty five days after transplanting, the treated plants were utilized to study the feeding activity of BPH through honey dew test.

Table 1. Dosage used in the study

Treatments	Dosage - Field dose (t ha^{-1})	Dosage – Pot experiment (g pot^{-1})
Bituminous fly ash (BFA)	1.0	5.0
Bituminous fly ash	2.5	12.5
Bituminous fly ash	5 .0	25.0
Bituminous fly ash	7.5	37.5
Bituminous fly ash	10.0	50.0
Bituminous fly ash	12.5	62.5
Lignite fly ash (LFA)	1 .0	5.0
Lignite fly ash	2.5	12.5
Lignite fly ash	5.0	25.0
Lignite fly ash	7.5	37.5
Lignite fly ash	10 .0	50.0
Lignite fly ash	12.5	62.5
Untreated check	-	-

For the pot culture experiment, the quantity of fly ash was calculated by following the standard technique taking top 10 cm layer of one hectare land contains 2,000,000 kg of soil and for 12.5 tonnes of fly ash ha^{-1} for 10 kg of pot soil, fly ash requirement is 62.5 g.

This test was carried out in the seedlings, 25 days after transplanting in the microplots exposed to various treatments. First the outer leaf sheath that was loose from the stem was cut at its base to prevent it from coming in contact with the filter paper. Plant was guided through a central hole in the round card board sheet of size 120 mm and it was placed at the base of the seedlings just one feet above water level. A modified method (Pathak and Heinrichs, 1982) of capturing honey dew droplets was followed. Whatman No.1 filter paper of size 90 mm was dipped in bromocresol green solution (2 mg ml^{-1} ethanol) and allowed to dry for one hour and was dipped again. The filter paper turned to orange (Fig. 1). The treated filter paper disc was placed just over the round card board sheet of size 120 mm. The feeding chamber consisted of an inverted transparent plastic cup placed over the filter paper resting on a round card board sheet and the plant was guided through the central hole.

Fifty adults of two-day old female BPH pre-starved for 5 hours were introduced into each feeding chamber through the hole at the top of the cup and the hole was plugged with the cotton. After 24 hrs of feeding, filter paper was removed. Immediately upon contact with honeydew (the excreta of BPH), blue spots appeared on the filter paper. As the quantity of the honey dew increased, the spots turned white in the centre with blue edges.

Thus, the feeding activity of the hoppers was estimated through computing the area of honey dew spots developed in the treatments. The honey dew spots developed is directly proportional to the actual feeding activity of hoppers and expressed in terms of sq. mm.

All laboratory experiments were carried out at 25 ± 5°C. The leaf sheath was collected from treated plants and untreated check maintained under pot culture conditions and utilized to analyze biochemical constituents such as phenol, silicon and tannin in rice

One gram of leaf sheath sample was ground in 10-20 ml of 80% ethanol. Homogenate was centrifuged at 10000 rpm for 20 minutes and the supernatant was collected. The residue was re-extracted and the supernatant pooled. The supernatant was evaporated to dryness. The residue dissolved in 5 ml of distilled water. Aliquots of 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8 and 2.0 were pipetted out into test tubes and the volume made upto 2 ml with water. To each tube 5 ml of 20% sodium carbonate was added and the contents were allowed to stand for 20 minutes. One ml of Folin ciocalteau reagent was added to all the tubes. After 30 minutes the absorbance was measured at 660nm in spectrophotometer. A standard curve was prepared using different concentrations of catechol. With the standard curve, the concentration of total phenols present in various treated samples was calculated.

Oven dried leaf sheath sample of 0.5 g was digested with triple acid and the digest was added with excess of sodium carbonate to dissolve the silica. The resultant solution was transferred to 250 ml polythene volumetric flask and made up to the volume. 2 ml of aliquot was pipetted out in to 50 ml standard polythene flask. 5 ml of 6 N HCl was added and agitated for a while to remove the CO_2 evolved. 2 ml of 10% ammonium molybdate pH 7-8 was added and mixed well. 0.5 ml of 5% hydroxylamine hydrochloride was added to remove iron interference. 1 ml of 10% oxalic acid was added to remove phosphorus interference. The resultant silica molybdate complex after dilution to volume was reduced by addition of 0.5% ascorbic acid and volume was made up to 50 ml. The blue colour developed was allowed to stand for 15-20 minutes and the intensity was read at 660 nm in a spectrophotometer. Similarly colour was developed for standards prepared from sodium meta silicate.

One gram of leaf sheath sample was ground using distilled water and taken in 250 ml conical flask, 75 ml of distilled water was added and boiled for 30 minutes. The solution was centrifuged at 2000 rpm for 20 minutes and the supernatant was collected in a 100ml volumetric flask and the volume was made upto 100 ml with distilled water. 1ml of sample extract was taken & transferred to 100 ml volumetric flask containing 75 ml of distilled water. 5 ml of Folin- Dennis reagent and 10 ml of sodium carbonate solution were added and the volume was made up to 100 ml. After 30 minutes, the mixture was shaken well and the absorbance was measured at 700nm. The standard curve was drawn using different concentrations of tannic acid. Using the standard curve, the tannin content of treated samples was calculated.

RESULTS AND DISCUSSION

The feeding behavior as estimated through honey dew excretion of BPH was significantly less in the effective treatment lignite fly ash at 10 t ha^{-1} (9.6 mm^2), LFA 12.5 at t ha^{-1} (10 mm^2) followed by bituminous fly ash at 12.5 t ha^{-1} (11 mm^2) as compared to untreated control

Table 2. Effect of fly ash on the feeding activity of brown planthopper and phenol, and tannin content in rice

Treatment	Honey dew (mm^2)*	Phenol ($mg\ g^{-1}$)*	Tannin ($mg\ g^{-1}$)*
Bituminous fly ash 1 t ha^{-1}	23.60 $(4.84)^{g}$	2.20 $(1.47)^{de}$	4.80 $(2.18)^{de}$
Bituminous fly ash 2.5t ha^{-1}	18.30 $(4.27)^{fg}$	2.50 $(1.58)^{de}$	5.60 $(2.37)^{d}$
Bituminous fly ash 5t ha^{-1}	14.00 $(3.73)^{bcdef}$	2.60 $(1.60)^{d}$	7.70 $(2.77)^{bc}$
Bituminous fly ash 7.5 t ha^{-1}	13.00 $(3.6)^{abcde}$	3.60 $(1.90)^{c}$	8.30 $(2.88)^{abc}$
Bituminous fly ash 10t ha^{-1}	11.60 $(3.4)^{abcd}$	3.50 $(1.88)^{c}$	8.43 $(2.89)^{ab}$
Bituminous fly ash 12.5t ha^{-1}	11.00 $(3.28)^{abc}$	5.40 $(2.33)^{a}$	8.60 $(2.93)^{ab}$
Lignite fly ash 1.0t ha^{-1}	15.67 $(3.91)^{def}$	2.30 $(1.56)^{de}$	4.50 $(2.12)^{e}$
Lignite fly ash 2.5t ha^{-1}	18.67 $(4.11)^{ef}$	2.20 $(1.79)^{c}$	5.50 $(2.38)^{d}$
Lignite fly ash 5.0t ha^{-1}	15.30 $(3.91)^{def}$	3.30 $(1.82)^{c}$	7.30 $(2.69)^{c}$
Lignite fly ash 7.5t ha^{-1}	14.30 $(3.78)^{cdef}$	4.60 $(2.14)^{b}$	9.03 $(2.99)^{a}$
Lignite fly ash 10.0t ha^{-1}	9.60 $(3.09)^{a}$	6.03 $(2.44)^{a}$	9.10 $(3.01)^{a}$
Lignite fly ash 12.5t ha^{-1}	10.00 $(3.15)^{ab}$	5.90 $(2.42)^{a}$	8.46 $(2.90)^{ab}$
Untreated check	51.60 $(7.16)^{h}$	2.06 $(1.43)^{e}$	2.43 $(1.55)^{f}$
CD (P<0.05)	0.6169	0.1585	0.0362

* Mean of three Replications

Figures in parentheses are square root transformed value

In a column, means followed by common letter(s) are not significantly different at P<0.05 by LSD.

(51.6 mm^2). (Table 2). The reason for the reduction of honey dew in various treatments might be due to high phenol (6.03 mg g^{-1}), silicon (2.5 %) and tannin (9.1 mg g^{-1}) contents in the fly ash treated plants. Similar results were reported from work at International Rice Research Institute (IRRI, 1988). The corresponding increase in total phenol, silicon and tannin in the treated plants play a vital role on lowering the incidence of BPH. This is in confirmatory with the findings of Subramaniam and Gopalswamy (1991) who revealed that at high levels of silicon, fewer planthopper nymphs became adults and there was a decrease in adult longevity and female fecundity.

Plants have their own defense mechanisms to protect them from attack by insect which include physical deterrents and biochemical substances which either act as chemical signals to discourage herbivorous activity or directly toxic to cause sterility or failure to reach sexual maturity (Levin, 1976) The total phenols, silicon and tannin content of plants treated with lignite fly ash (LFA) at 10 t^{-1} was 6.03 mg g^{-1}, 2.6 % and 9.1 mg g^{-1}, respectively, and were significantly high when compared to untreated check where the phenol, silicon and tannin content recorded were 2.06 mg g^{-1}, 1.0% and 2.43 mg g^{-1}, respectively (Table 2 and Fig. 1). The corresponding increase in total phenol, silicon and tannin in the treated plants play a vital role on lowering the incidence of BPH. The findings of Ashoka Rani *et al*. (1997) revealed that in rice plants, supply of Si also changed the contents of carbohydrate, protein, phenol and showed positive relationship. It has also been observed that soluble silicic acid in rice plants strongly inhibits the feeding activity of BPH even at low concentrations (0.01 mg Si ml^{-1}), whereas more phenol content in rice is negatively correlated with the incidence of WBPH (Mishra and Misra, 1992; Rath and Misra, 1998 and Nalini 2000).

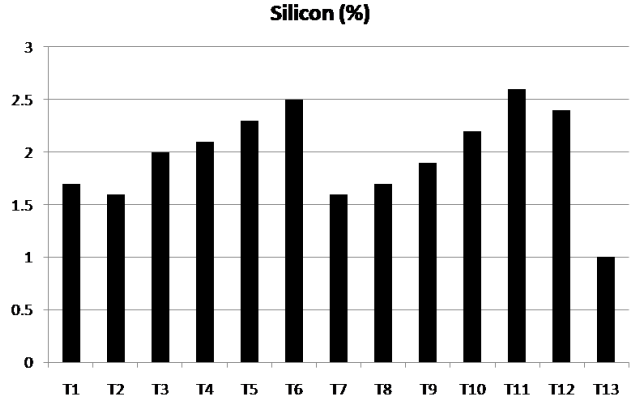

Fig. 1. Influence of fly ash on silicon content of the host plant.

Rajeshwari (2000) also reported that reducing, non reducing and total sugar content were low and total phenols and silica content were high in plants with lignite fly ash applied basally. The present work is in confirmatory with the findings of Chandramani *et al.* (2003) that application of FYM, neem cake, biofertilizer and lignite fly ash significantly enhanced the defensive chemicals *viz*., phenol, tannin and silica and exhibiting resistance in terms of antibiosis by means of reducing the feeding rate, fecundity, oviposition period, longevity, adult emergence, population built up, lengthening nymphal period in sucking insects in rice. The antibiosis mechanism obtained by the effective treatment was in agreement with the findings of Painter (1951) and Khan and Saxena (1985)

To summarise, application of fly ash significantly enhanced the defensive chemicals *viz*., phenol, silicon and tannin exhibiting resistance in terms of antibiosis by means of reducing the feeding behaviour of BPH in rice.

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